Comparative Climatology of Terrestrial Planets

June 25–28, 2012

Program

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Comparative Climatology of Terrestrial Planets

June 25–28, 2012 • Boulder, Colorado

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The Planetary Society

CONVENERS

Mark A. Bullock, *Department of Space Studies, Southwest Research Institute*
Waleed Abdalati, *Chief Scientist, NASA*
Richard S. Eckman, *Earth Science Division, NASA*
Lori S. Glaze, *Planetary Geodynamics Laboratory, NASA Goddard Space Flight Center*
Jim Green, *Planetary Science Division, NASA*
David H. Grinspoon, *Denver Museum of Nature and Science*
Madhulika Guhathakurta, *Heliophysics Division, NASA*
James E. Hansen, *NASA Goddard Institute for Space Studies*
Sanjay S. Limaye, *Space Science and Engineering Center, University of Wisconsin*
Stephen Mackwell, *Lunar and Planetary Institute*
Adriana Ocampo, *Planetary Science Division, NASA*
Mario R. Perez, *Astrophysics Division, NASA*
Suzanne E. Smrekar, *Jet Propulsion Laboratory*

Lunar and Planetary Institute 3600 Bay Area Boulevard Houston TX 77058-1113

Guide to Technical Sessions

Sunday, June 24, 2012

6:00 p.m.	Boulderado Foyer	Reception and Registration

Monday, June 25, 2012

8:15 a.m.	Boulderado Ballroom	Climate Change on Earth and the Terrestrial Planets
11:00 a.m.	Boulderado Ballroom	Terrestrial Planet Climate Models
1:30 p.m.	Boulderado Ballroom	Exoplanet Atmospheres
4:00 p.m.	Boulderado Ballroom	NASA Perspectives on Comparative Climate Research

Tuesday, June 26, 2012

8:30 a.m.	Boulderado Ballroom	Earth and Terrestrial Planet Climate Models
10:30 a.m.	Boulderado Ballroom	Terrestrial Planet Atmospheres
3:00 p.m.	Boulderado Ballroom	Exoplanet Observations and Chemistry
4:00 p.m.	Boulderado Ballroom	Comparison of Radiative Effects of Clouds on Earth and the Terrestrial Planets
8:00 p.m.	Boulder Theater	Public Event with Bill Nye ("The Science Guy") "Climate Change on Earth and Other Planets," a public Q&A event with panelists Jim Hansen, Brian Toon, and David Grinspoon

Wednesday, June 27, 2012

8:30 a.m.	Boulderado Ballroom	Solar-Atmosphere Interactions
11:00 a.m.	Boulderado Ballroom	Interior-Atmosphere Interactions
1:30 p.m.	Boulderado Ballroom	Geology and Climate on the Terrestrial Planets
5:30 p.m.	Rembrandt Yard	Poster Session and Reception

Terrestrial Planet Atmospheres and Climates: Observational Basis
Terrestrial Planet Atmospheres and Climates: Theory and Models
Photochemistry
Exoplanet Atmospheres
Solar-Atmosphere Interactions
Interior-Surface-Atmosphere Interactions

Thursday, June 28, 2012

8:30 a.m.	Boulderado Ballroom	Solar Effects on Terrestrial Planet Climates
10:30 a.m.	Boulderado Ballroom	Terrestrial Planet Exploration
1:30 p.m.	Boulderado Ballroom	Terrestrial Planet Climate
4:00 p.m.	Boulderado Ballroom	Plan Forward for Comparative Climatology

Monday, June 25, 2012
CLIMATE CHANGE ON EARTH AND THE TERRESTRIAL PLANETS
8:15 a.m. Boulderado Ballroom

Comparisons of the greenhouse effect, upper atmospheres, and climate evolution of the Earth and terrestrial planets

Chairs: **Waleed Abdalati**
Brian Drouin

8:15 a.m. Abdalati W. *
Introductory Remarks

8:30 a.m. Hansen J. * Kharecha P. Lacis A. Russell G. Sato M.
Venus Syndrome **[#8070]**
We use three alternative avenues to investigate climate sensitivity on Earth and the conditions that could lead to extermination of human life on the planet or even a Venus-like runaway greenhouse effect.

9:00 a.m. Goldblatt C. * Crisp D. Robinson T. Watson A. Zahnle K.
The Runaway Greenhouse: New Model Results and Implications for Planets and Anthropogenic Global Change **[#8095]**
The ultimate and final end for Earth as a habitable planet will be the transition to a "runaway greenhouse," an apocalypse triggered by failure of the planet to maintain energy balance.

9:30 a.m. Crisp D. *
CO_2 Greenhouse Effects on Venus, Earth, and Mars **[#8083]**
Carbon dioxide (CO_2) is an efficient, long-lived greenhouse gas that has played a key role in the evolution of the climates of Venus, Earth, and Mars.

10:00 a.m. Solomon S. C. *
An Introduction to Terrestrial Ionospheres **[#8009]**
This presentation will briefly describe the ionospheres of Earth, Venus, and Mars; explain how ions are produced and destroyed; and offer a hypothesis for why these terrestrial planet ionospheres differ in fundamental aspects.

10:30 a.m. BREAK

TERRESTRIAL PLANET CLIMATE MODELS
11:15 a.m. Boulderado Ballroom

Global climate models of the terrestrial planets and runaway greenhouses

Chairs: **David Grinspoon**
Colin Goldblatt

11:15 a.m. Forget F. *
Global Climate Models of the Terrestrial Planets **[#8073]**
Global climate models initially designed for Earth can be adapted to the other planets. The goal is to build virtual planets "behaving" like the real ones. Of course, nature is always more complex, but we learn a lot in the process.

11:45 a.m. Pierrehumbert R. T. *
The Runaway Greenhouse: Could it Happen Here? **[#8035]**
The runaway greenhouse is the main determinant of the inner edge of the habitable zone. I discuss the conditions for occurrence, with particular attention to the question of whether it can be triggered by increases in CO_2, on Earth or elsewhere.

Monday, June 25, 2012
EXOPLANET ATMOSPHERES
1:30 p.m. Boulderado Ballroom

The nature and dynamics of exoplanet atmospheres are explored, and detection methods are discussed

Chairs: **Franck Montmessin**
Owen Toon

1:30 p.m. Swain M. *
Exploring Worlds Around Other Stars **[#8080]**
A technique that is revolutionizing our understanding of exoplanet atmospheres is observations of transiting exoplanets. These are planetary systems that are oriented so that the planet appears to pass in front of the parent star.

2:00 p.m. Gaidos E. *
Some Plausible Atmospheres of Small Kepler Planets **[#8037]**
I will discuss some plausible scenarios for the atmospheres of the Earth- to Neptune-sized planets that the Kepler mission has discovered, focusing on H_2, He, and H_2O.

2:30 p.m. Showman A. P. * Wordsworth R. D. Merlis T. M.
Atmospheric Circulation of Terrestrial Exoplanets **[#8090]**
We summarize the theory of atmospheric circulation of terrestrial exoplanets, discuss how the circulation interacts with the climate to help shape planetary habitability, and summarize recent numerical studies of the circulation on these planets.

3:00 p.m. Kaspi Y. *
Shallow Versus Deeply Forced Atmospheric Dynamics **[#8071]**
We discuss the dynamical differences in atmospheric circulation between atmospheres driven by shallow forcing from their parent star, and deep atmospheres driven by internal convection. We show how deep dynamics can be probed by gravity measurements.

3:30 p.m. BREAK

NASA PERSPECTIVES ON COMPARATIVE CLIMATE RESEARCH
4:00 p.m. Boulderado Ballroom

Panel discussion focused on NASA perspectives on the future of comparative climate research

Panel Members: Alan Stern, *Southwest Research Institute (SwRI)*
John Grunsfeld, *NASA Associate Administrator*
Waleed Abdalati, *NASA Headquarters Chief Scientist*

Tuesday, June 26, 2012
EARTH AND TERRESTRIAL PLANET CLIMATE MODELS
8:30 a.m. Boulderado Ballroom

The physics of atmospheres is discussed, followed by descriptions of terrestrial planet climate models

Chairs: **Sanjay Limaye**
Jeffery Hollingsworth

8:30 a.m. Schubert G. * Mitchell J.
Planetary Atmospheres as Heat Engines **[#8032]**
We review the workings of Earth's atmospheric heat engine and describe the energy exchanges that support the atmospheric circulation. We apply these concepts to Venus, Mars, and Titan.

9:00 a.m. Covey C. * Haberle R. M. McKay C. P. Titov D. V.
The Greenhouse Effect and Climate Feedbacks **[#8026]**
We review the theory of the greenhouse effect and climate feedback. We also compare the theory with observations, using examples taken from all four known terrestrial worlds with substantial atmospheres: Venus, Earth, Mars, and Titan.

9:30 a.m. Ramanathan V. *
Resolving Outstanding Issues in Climate Change with Unmanned Aerial Vehicle (UAVs)

10:00 a.m. Read P. L. * Lewis S. R. Mendonca J. Montabone L. Mulholland D. P. Ruan T. Wang Y.
Climate Regimes on Terrestrial Planets Within a Hierarchy of Dynamical Models **[#8048]**
We present an overview of the circulation regimes that may be exhibited in simplified and full-physics GCMs. These include cases that correspond to Earth, Mars, Titan, and Venus, classified by dimensionless numbers such as the thermal Rossby number.

10:30 a.m. BREAK

TERRESTRIAL PLANET ATMOSPHERES
11:00 a.m. Boulderado Ballroom

The dynamics of terrestrial planet atmospheres and influences on climate

Chairs: **Stephen Bougher**
Peter Read

11:00 a.m. Lebonnois S. *
The Mechanism of Superrotation in Venus and Titan LMD GCM **[#8004]**
Venus and Titan atmospheres both feature the superrotation phenomenon. In this presentation, we use the LMD general circulation models developed for these atmospheres to show similarities and differences in the mechanism maintaining superrotation.

11:30 a.m. Lee C. * Richardson M. I. Newman C. E. Lian Y.
Superrotation in a Venus GCM with Realistic Radiative Forcing **[#8066]**
This presentation will discuss the Ashima Research Venus GCM with an integrated radiation scheme that simulates realistic solar and infrared fluxes. We will show simulations using this GCM that develop superrotation and SS-AS circulation.

12:00 LUNCH

Tuesday, June 26, 2012
TERRESTRIAL PLANET ATMOSPHERES (continued)
1:30 p.m. Boulderado Ballroom

The dynamics of terrestrial planet atmospheres and influences on climate

Chairs: **Stephen Bougher**
Peter Read

1:30 p.m. Rafkin S. C. R. * Hollingsworth J. L. Mischna M. A. Newman C. E. Richardson M. I.
Mars Climate: The Biography **[#8052]**
Mars' atmosphere shares a great number of characteristics with Earth. At the same time, there are significant differences. We review the basic climate and circulations of Mars and highlight open questions regarding its climate and evolution.

2:00 p.m. Hollingsworth J. L. * Kahre M. A.
Extratropical Cyclogenesis and Frontal Waves on Mars: Influences on Dust, Weather and the Planet's Climate **[#8075]**
This is a modeling investigation on extratropical cyclogenesis and frontal waves on Mars, and the influences such disturbances have on dust and the planet's climate.

2:30 p.m. Zent A. P. *
Orbital Effects on the Climates of Terrestrial Planets **[#8068]**
The consequences of oscillations in orbital parameters for both the terrestrial and martian climates are reviewed.

3:00 p.m. BREAK

EXOPLANET OBSERVATIONS AND CHEMISTRY
3:30 p.m. Boulderado Ballroom

Observations and modeling of exoplanet atmospheres

Chairs: **Adam Showman**
Eric Gaidos

3:30 p.m. Harrington J. * UCF Exoplanets Group
Model-Free Identification of two Classes of Exoplanets **[#8036]**
We compare the emitted fluxes of over 30 exoplanet atmospheres measured in secondary eclipse. Planets hotter than about 2000 K emit more than a Planck scaling predicts. More than one hypothesis may explain the data.

4:00 p.m. Visscher C. *
Chemical Processes in Exoplanet Atmospheres **[#8046]**
We will use the results of chemical models to explore how the major chemical processes — thermochemistry (including condensation), quench chemistry, and photochemistry — shape the observational characteristics of extrasolar planets.

Tuesday, June 26, 2012
COMPARISON OF RADIATIVE EFFECTS OF CLOUDS ON EARTH AND THE TERRESTRIAL PLANETS
4:30 p.m. Boulderado Ballroom

Panel discussion focused on radiative effects of clouds on each of the terrestrial planets

Panel Members: Franck Montmessin, *Centre National de la Recherche Scientifique (CNRS)*
Curt Covey, *Lawrence Livermore National Laboratory (LLNL)*
Veerabhadran Ramanathan, *SCRIPPS*

Wednesday, June 27, 2012
SOLAR-ATMOSPHERE INTERACTIONS
8:30 a.m. Boulderado Ballroom

Responses of the upper atmosphere of terrestrial planets to variations in the radiative and particle flux from the Sun

Chairs: **Thomas Cravens**
Feng Tian

8:30 a.m. Brain D. A. * Leblanc F. Luhmann J. G. Moore T. E. Tian F.
Planetary Magnetic Fields and Climate Evolution **[#8049]**
In this presentation we review the ways in which the presence (or absence) of a planetary magnetic field can influence climate, and provide specific examples using Earth, Venus, Mars, and Titan. We then identify future needs in this research area.

9:00 a.m. Woods T. N. *
Solar Ultraviolet Variability over Time Periods of Aeronomic Interest **[#8093]**
The solar ultraviolet radiation is a primary energy source for planetary atmospheres and is also a tool for remote sensing of the planets.

9:30 a.m. Bougher S. W. * Brecht A. S. McDunn T. L. Solomon S. C.
Solar Influences on the Structure and Dynamics of the Venus, Earth, and Mars Upper Atmospheres: Implications for Neutral Atmospheric Loss Processes **[#8043]**
The upper atmospheres of Venus, Earth, and Mars change dramatically over time since they are controlled in part by highly variable solar EUV-UV fluxes over the solar cycle. These thermosphere-ionosphere variations also regulate key escape mechanisms.

10:00 a.m. Pawlowski D. J. * Bougher S.
Comparative Aeronomy: The Effects of Solar Flares at Earth and Mars **[#8086]**
This presentation will focus on comparative aspects of the response of the Earth and Mars thermosphere and ionosphere systems response to dynamic forcing during solar flare events.

10:30 a.m. BREAK

INTERIOR-ATMOSPHERE INTERACTIONS
11:00 a.m. Boulderado Ballroom

Early atmospheres and evolution due to volatiles degassed from planetary interiors

Chairs: **Elizabeth Turtle**
Suzanne Smrekar

11:00 a.m. Elkins-Tanton L. T. *
Compositional Ranges for the Earliest Atmospheres Degassed from Rocky Planets **[#8020]**
Terrestrial planets are likely to obtain their first planetary atmospheres through degassing during accretion. Here we examine the likely range of compositions of earliest degassed atmospheres.

11:30 a.m. Sotin C. * Smrekar S. E.
Interior Dynamics and Outgassing of Volatiles on Titan, Venus, and Mars **[#8079]**
The examples of ^{40}Ar and water (methane for Titan) are used to illustrate how measurements on atmospheric composition can provide insights on the interior dynamics of planets.

Wednesday, June 27, 2012
GEOLOGY AND CLIMATE ON THE TERRESTRIAL PLANETS
1:30 p.m. Boulderado Ballroom

Climate and surface morphology are shaped by volcanic outgassing, precipitation, and volatile cycles, with similarities and differences evident across the terrestrial planets

Chairs: **Elizabeth Turtle**
Suzanne Smrekar

1:30 p.m. Coffin M. F. *
Some Environmental Consequences of Large Igneous Provinces **[#8034]**
The formation of LIPs may impact the atmosphere, oceans, and biosphere by rapidly releasing huge amounts of particulates, magmatic volatiles, and potentially volatiles from intruded sediments. Resulting environmental changes can be global in extent.

2:00 p.m. Smrekar S. E. * Sotin C.
Venus Volatiles, Climate, Surface and Interior Evolution: A Terrestrial Planet Gone Bad **[#8072]**
On Venus, the history of resurfacing, climate, and present day volcanism provide insights on the interior evolution and the history of outgassing of water and CO_2 in shaping the planet most similar to, yet so different from, Earth.

2:30 p.m. Glaze L. S. * Self S. Baloga S. M. Stofan E. R.
Volatile Transport by Volcanic Plumes on Earth, Venus and Mars **[#8011]**
Explosive volcanic eruptions transport volcanic volatiles to great heights in the atmospheres of Earth, Venus and Mars, and can redistribute chemical species by entraining ambient atmosphere at low altitudes and releasing them at higher altitudes.

3:00 p.m. Howard A. D. * Irwin R. P. III Moore J. M. Craddock R. A. Matsubara Y. Wilson S. A. Hobley D. E.
Implications of Fluvio-Lacustrine Landforms to the Climate Evolution of Mars **[#8010]**
Noachian mars was dry but eroded. Mars at the Noachian-Hesperian was wetter. Mars during the Hesperian to Amazonian supported limited fluvial incision.

3:30 p.m. BREAK

4:00 p.m. Turtle E. P. *
The Role of Precipitation in Landform Evolution on Titan **[#8084]**
Titan is one of only a few places in the solar system with an active hydrologic cycle, including precipitation. And, as on Earth and Mars, Titan's landscape shows significant evidence of surface modification as a result of precipitation.

4:30 p.m. Moore J. M. * Howard A. D.
Climate Change on Titan: Hypotheses and the Geological Record **[#8018]**
Titan's landscape is profoundly shaped by its atmosphere. Hypotheses of Titan's climatic evolution fall into three broad categories regulated by the role, sources, and availability of methane: steady state, progressive, and cyclic.

Wednesday, June 27, 2012
POSTER SESSION:
TERRESTRIAL PLANET ATMOSPHERES AND CLIMATES: OBSERVATIONAL BASIS
5:30 p.m. Rembrandt Yard

Esposito L. W. Colaprete A. English J. M. Haberle R. M. Kahre M. A.
Clouds and Aerosols on Terrestrial Planets **[#8013]**
We discuss measurement techniques and the nature of Venus, Earth, and Mars clouds. We suggest important future investigations, models, and comparisons for terrestrial planet aerosols.

Määttänen A. Pérot K. Hauchecorne A. Montmessin F. Bertaux J.-L.
A Comparison of the Mesospheric Clouds on Mars and on the Earth **[#8040]**
We will present an overview of mesospheric cloud observations on the Earth and on Mars, discuss their similarities and differences, and the possible (similar) formation mechanisms related to atmospheric circulations and microphysics.

Mahieux A. Robert S. Wilquet V. Drummond R. Vandaele A. C. Montmessin F. Bertaux J. L.
Venus Atmosphere from SOIR Measurements at the Terminator (VAST) **[#8019]**
The SOIR instrument is an IR spectrometer performing solar occultations. It probes the Venus atmosphere between 70 and 170 km, and among many species it allows to derive CO_2 density and temperature profiles in this altitude range.

Guzewich S. D. Talaat E. R. Toigo A. D. Waugh D. W. McConnochie T. H.
Inter-Annual Variability of High-Altitude Dust Layers on Mars and Their Connection with the General Circulation **[#8025]**
Mars atmospheric observations indicate high-altitude local maxima in dust mixing ratios near 15–30 km and above 45 km. This signficant departure from the Conrath-ν dust profile creates notable changes in the simulated general circulation.

Whiteway J. Dickinson C. Komguem L. Daerden F.
LIDAR Observations of Dust, Clouds, and Precipitation on Mars and Earth **[#8054]**
The LIDAR instrument on the Phoenix Mars mission detected the backscatter of pulsed laser light to measure the vertical distribution of atmospheric dust and water ice clouds. LIDAR measurements on Mars and Earth will be compared.

Titov D. V. Svedhem H. Markiewicz W. J. Piccioni G.
Structure, Morphology and Radiative Effects of the Clouds Derived from Venus Express Observations **[#8077]**
The paper will present an overview of the Venus Express observations of the cloud morphology and structure and implications for the radiative energy balance of the Venus atmosphere.

TERRESTRIAL PLANET ATMOSPHERES AND CLIMATES: THEORY AND MODELS

Londhe V. D.
Comparative Terrestrial Planet Simulation Model **[#8002]**
The model gives the different comparative details of the various terrestrial planets. Our own solar system is the best model of the habitat system. The habitability depends on the factors such as precise distance from the host star, etc.

Kochemasov G. G.
Atmospheres of Venus, Earth, and Mars: Their Masses and Granulations in Relation to Orbits and Rotations of the Planets **[#8008]**
Masses and granulations (climate cells) of terrestrial planets atmospheres are related to their orbital frequencies as well as to rotation speeds. Tectonic lithospheric granules have a direct connection with atmospheric structures.

Zalucha A. M.
Demonstration of a GCM for Mars, GJ 1214b, Pluto, and Triton **[#8016]**
The MIT GCM dynamical core, in conjunction with the appropriate RT schemes, has been adapted to simulate many planetary bodies: Mars, super-Earth GJ 1214b, Pluto, and Triton. Current applications of the GCM will be demonstrated here.

Parish H. F. Lebonnois S. Schubert G. Covey C. Walterscheid R. L. Grossman A.
Importance of the Angular Momentum Budget in Venus Atmosphere Circulation Models **[#8017]**
We examine the angular momentum budget for different Venus general circulation models. We find that if there is weak angular momentum forcing, numerical diffusion and residual numerical torques can dominate and give unphysical results.

Mandt K. E. Waite J. H. Jr. Nixon C. A. Mousis O.
The Evolution of Titan's Atmosphere and Implications for Climate Change **[#8027]**
The origin of Titan's atmosphere and the history of its methane is a subject of great interest. We use isotopic fractionation to learn about the origin and early history of nitrogen and to set an upper limit for methane timescale.

Azriel M. S. Hill H. G. M.
Planetary Engineering of Venus for Earth **[#8031]**
Venus has potential to serve as a test bed for planetary engineering technologies also applicable to Earth, while modulating Venus' environment. This may enable additional missions to Venus and provide insights for atmospheric modification of Earth.

Kuroda T. Terada N. Kasai Y. Kasaba Y.
Modeling of the Atmospheric Water Cycle Including the Isotopic Ratio on Mars **[#8033]**
We are starting the GCM simulations of water cycle including HDO on Mars. Here we show our preliminary results and future plans connecting from the underground water to the escape processes to the space.

Mendonca J. M. Read P. L. Lewis S. R. Lee C.
The New Oxford Planetary Unified Model System for Venus (OPUS-V) **[#8047]**
We present a new version of the Oxford Venus GCM, which using our new parameterisations produce a realistic Venus mesosphere atmospheric circulation. We present results that give hints to the formation of global super-rotation.

Lewis S. R. Dawson J. Read P. L. Mendonca J. Ruan T. Montabone L.
Super-Rotating Jets in the Atmospheres of Terrestrial Planets **[#8051]**
Super-rotation is a ubiquitous phenomenon in the four substantial atmospheres possessed by solid bodies in the solar system. This paper reviews recent global model results and reanalyses by data assimilation, in particular for Mars and Venus.

Mooring T. A. Wilson R. J. Vallis G. K.
Regularity of Baroclinic Waves in the Terrestrial and Martian Atmospheres **[#8061]**
The winter northern hemisphere of Mars exhibits highly regular baroclinic waves, but understanding of the cause of their regularity remains incomplete. We present preliminary results of an investigation of this phenomenon using a GCM.

Kahre M. A. Hollingsworth J. L. Haberle R. M.
Simulating Mars' Dust Cycle with a Mars General Circulation Model: Effects of Water Ice Cloud Formation on Dust Lifting Strength and Seasonality **[#8062]**
The effects of coupling Mars' dust and water cycles on dust lifting strength and seasonality are investigated with a Mars general circulation model.

Wilson R. J.
Martian Dust Storms, Thermal Tides, and the Hadley Circulation **[#8069]**
The Hadley circulation and the thermal tides are prominent circulation elements in the martian atmosphere. They are sensitive to changes in thermal forcing and lead to a strong coupling between dust lifting by the circulation and radiative heating.

PHOTOCHEMISTRY

Delgado-Bonal A. Martín-Torres F. J. Simoncini E.
Effect of Radiative Transfer in the Photochemistry of Rocky Planets Atmospheres **[#8076]**
Photochemistry and radiative transfer are two deeply related fields of study that are usually studied separately. As the atmospheric temperature is strongly related to its chemical composition and their evolutions must be considered simultaneously.

Cottini V. Achterberg R. K. Bjoraker G. L. Romani P. Bezard B. Lellouch E.
Oxygen Compounds Abundance in Titan's Stratosphere from Cassini/CIRS Data **[#8089]**
In this work we analyze the signatures of carbon monoxide (CO) and water (H_2O) in the far infrared spectra of Titan acquired by the Composite InfraRed Spectrometer (CIRS) onboard the Cassini mission to the saturnian system.

Yoon Y. H. Trainer M. G. Tolbert M. A.
Influence of Benzene on the Optical Properties of Titan Haze Laboratory Analogs in the Mid-Visible **[#8029]**
Using cavity ring-down aerosol extinction spectroscopy, we determine the real and imaginary refractive index at 532 nm of particles formed by benzene photolysis and Titan analog particles formed with ppm-levels of benzene.

Wilson E. H. Atreya S. K.
Conditions for Haze Formation in Planetary Atmospheres — A Comparative Study Among the Atmospheres of Early Earth, Early Titan, and Present-Day Titan **[#8003]**
A photochemical model is used to examine the mechanisms and efficiency of haze formation and assess the impact of atmospheric haze on the evolution of the atmospheres of early Earth, early Titan, and present-day Titan.

Horst S. M. Yoon Y. H. Hicks R. K. Tolbert M. A.
Understanding the Effect of Carbon Monoxide on the Formation and Composition of Planetary Atmospheric Hazes **[#8045]**
A comparison of the composition aerosols produced from $N_2/CH_4/CO$ gas mixtures using two different energy sources (spark, FUV) and the effect of variation of CO mixing ratio on aerosol production and composition will be presented.

Drouin B. J. Brown L. R. Miller C. E. Pearson J. C. Sung K. Yu S.
High Resolution Laboratory Spectroscopy of Hot and Cold Atmospheres **[#8014]**
A strong effort is in place in the JPL Molecular Spectroscopy Group to provide fundamental knowledge to support ground-, aircraft-, and space-based atmospheric spectroscopy. We present high-resolution laboratory spectroscopy of atmospheric molecules.

Drouin B. J. Pearson J. C.
Collisional Cooling Apparatus for Studying Cold Atmospheres **[#8015]**
A technique enabling cryogenic gas-phase spectroscopic measurements is presented.

Hosseini S. S. Harris W. M.
Introducing Tunable Special Heterodyne in Studying Climatology of Terrestrial Planets **[#8059]**
There is a critical need to study extended targets (wide FOV) at high resolving powers in terrestrial climatology. We believe an emerging technique, Special Heterodyne Spectrometers, would fulfill this need.

EXOPLANET ATMOSPHERES

DeMarines J.
Challenges of Using Earth's Atmosphere as a Proxy for Detecting Biosignatures on Extrasolar Planets **[#8085]**
Assessing the challenges associated with the detectability of primitive biosignatures present on early Earth (methane and ethane) and addressing the observational difficulties when we begin to observe extrasolar atmospheres with a TPF-O mission.

Nakajima K. Noda S. Ishiwatari M. Takahashi Y. O. Takehiro S. Morikawa Y. Nishizawa S. Hayashi Y.-Y.
Atmospheric General Circulations of Synchronously Rotating Terrestrial Planets: Dependence on Planetary Rotation Rate **[#8060]**
Using a general circulation model, we investigate how climate over water covered, synchronously rotating planet vary as planetary rotation rate change. We find large variety of circulation, which, however, does not affect zonal heat transport.

Kataria T. Showman A. P. Fortney J. J. Marley M. S. Freedman R. S.
Atmospheric Circulation on GJ 1214b: Dependence on Composition and Metallicity **[#8063]**
We present 3-D atmospheric circulation models of GJ1214b using the SPARC/MITgcm, a general circulation model coupled to a plane-parallel, two-stream, multi-band radiative transfer model. Here, we focus on the dependence of metallicity and composition.

SOLAR-ATMOSPHERE INTERACTIONS

Stangier T. Sornig M. Sonnabend G.
Direct Wind Measurements in the Atmospheres of Mars, Earth and Venus **[#8005]**
Infrared heterodyne spectroscopy enables ground-based observations of fully resolved molecular transitions of CO_2 on Mars and Venus and O_3 in the Earth atmosphere on which direct line-of-sight wind velocities can be derived and compared.

Machado P. Widemann T. Luz D. Peralta J. Chanberlain S.
Observation of Dynamical Tracers in the Venus Atmosphere **[#8021]**
Renewed interest in measuring the winds at clouds top from the ground has emerged in the course of the Venus Express mission. Doppler shifts in solar Fraunhofer lines have provided the only Doppler wind measurements near the cloud tops.

Brecht A. S. Bougher S. W. Bell J. M.
Upper Atmosphere Thermal Structure in Slow Rotator Atmospheres: Venus vs. Titan **[#8030]**
Venus and Titan are slow rotating bodies with a thick atmosphere; that are in different environments due to their location. This work will compare the planets' thermal structure and investigate the importance of dynamics in each thermal structure.

Piccialli A. Titov D. V. Svedhem H. Markiewicz W. J.
Gravity Waves in Venus Mesosphere Observed by the Venus Monitoring Camera (VMC/VEx), and Comparison to Earth and Mars **[#8028]**
High-resolution images of Venus' northern hemisphere obtained with VMC/VEx allow to study small-scale features like wave trains. We present a statistical analysis of the wave properties aimed to characterize the wave types and their possible origin.

Tellmann S. Häusler B. Hinson D. P. Tyler G. L. Andert T. P. Bird M. K. Imamura T. Pätzold M. Remus S.
Small-Scale Wave Structures in the Venus Atmosphere as seen by the Radio Science Experiment VeRa on Venus Express **[#8044]**
The VeRa Experiment is able to detect small-scale temperature fluctuations in the upper troposphere and mesosphere of Venus with a high vertical resolution.

Ando H. Imamura T. Tsuda T.
Vertical Wavenumber Spectra of Gravity Waves in the Martian Atmosphere Obtained from the Mars Global Surveyor Radio Occultation Data **[#8022]**
Vertical wavenumber spectra of martian gravity waves are obtained and similar to those obtained in the terrestrial stratosphere and mesosphere. Moreover gravity wave saturation seems to occur in the atmosphere of Mars as well as that of the Earth.

McDunn T. Bougher S. W. Mischna M. Murphy J.
Gravity Waves' Influence on the Middle Atmosphere: A Comparison Between Mars and Earth **[#8082]**
We show that gravity wave momentum deposition is important for the thermal structure of the martian middle atmosphere and explore the similarities to its impact at Earth.

Gray C. L. Chanover N. J. Slanger T. G.
Oxygen Green Line Emission on Venus and its Connection to Solar Flares **[#8067]**
A review of the venusian atomic oxygen nightglow feature at 557.7 nm shows a correlation between emission strength and solar flare occurrences. We present recent nightglow observations after an M-class flare occurred directed toward Venus.

Migliorini A. Piccioni G. Capaccioni F. Filacchione G. Tosi F. Politi R. Drossart P.
Airglow Emissions in the Terrestrial Atmospheres **[#8006]**
The VIRTIS spectrometers are flying onboard Venus Express and Rosetta missions. They provide the unique opportunity to investigate and compare results about the oxygen and OH airglow emissions on the terrestrial planets.

Gronoff G. Mertens C. J. Norman R. Simon Wedlund C.
Comparative Ionizations of the Atmospheres of Mars, Titan, and the Earth **[#8087]**
In this study, we compute the ionizations in the whole atmospheres of Mars, Titan, and Earth. From these calculation, we compare the magnitude of the ionizations as a function of the altitude, and we compare the effects of these ionizations.

Molaverdikhani K. Brain D. A. Futaana Y. Hara T.
Venus Ionophere Map Based on Photoelectron Measurements by Venus Express's ELS Instrument on ASPERA-4 **[#8058]**
We present the results of our analysis of VEX data showing how the vertical extent of the ionosphere varies with solar wind drivers. We compare them to previous analyses using PVO observations and results obtained using a similar methodology at Mars.

Chaffin M. S. Schneider N. M. Stewart I. A. Chaufray J. Y.
Hydrogen Escape from Mars: Implications for Water Loss **[#8064]**
Using Mars Express observations of coronal Lyman alpha, we estimate contemporary atomic hydrogen escape rates and their variability, with implications for the long-term water loss history of Mars.

Harder J. W. Fontenla J. M. Merkel A. W. Woods T. N.
Measured and Modeled Trends in Solar Spectral Variability and Application to Earth Atmospheric Studies **[#8096]**
The Spectral Irradiance Monitor (SIM) and the Solar Stellar Intercomparison Experiments (SOLSTICE) onboard the Solar Radiation and Climate Experiment (SORCE) measure solar spectral variability.

INTERIOR-SURFACE-ATMOSPHERE INTERACTIONS

Miura Yas.
New Formation Model of Carbon-Bearing Atmospheres on Air-Planets of Earth, Venus and Mars **[#8038]**
New formation model of Earth, Venus, Mars, and the Moon is proposed by impacts on breccias, followed to form porous regolith soils for interior volatile storages, and lifted by volcanic activity, though Earth produces hard crust with different air.

Imamura T.
Thermally Forced Axi-Asymmetric Circulation in Venus's Lower Atmosphere **[#8050]**
Possible existence of global-scale, heat-induced circulation in Venus's lower atmosphere is studied using an analytical technique. Topographic rises including Aphrodite terra in the equatorial region provide the heat source.

Carter L. M. Campbell B. A. Glaze L. S.
Comparing Volcanic Terrains on Venus and Earth: How Prevalent are Pyroclastic Deposits on Venus? **[#8012]**
Radar imaging polarimetry data for Venus shows evidence of pyroclastic deposits. Placing constraints on the extent of explosive volcanism can provide boundary conditions for timing, volumes, and altitudes for atmospheric injection of volatiles.

Airey M. W. Mather T. A. Pyle D. M. Aplin K. L. Taylor F. W. Wilson C. F. Ghail R. C.
Volcanism as an Active Planetary Process on Venus **[#8023]**
The aim of this project is to characterise volcanism on Venus and its long-term effects on Venus' climate and planetary evolution. Analyses of radar data, mathematical modelling, and laboratory experiments will be implemented in the investigation.

Nuding D. L. Gough R. V. Tolbert M. A.
Water Uptake of Mars Salt Analogs: An Investigation of Stable Aqueous Solutions on Mars Using Raman Microscopy **[#8056]**
To understand the formation of briny aqueous solutions on Mars, salt analogs were developed to closely match the cation and anion concentrations as reported by Wet Chemistry Laboratory.

Parsons R. A. Moore J. M. Howard A. D.
Water Volume and Timescale Estimates for Valley Formation During the Late Hesperian to Early Amazonian, Mars **[#8078]**
Applying sediment transport theory to martian valleys for a range of channel depths and sediment grain sizes suggest that the cumulative duration of fluvial activity lasted 0.1 to 10 yrs, and the largest valleys were cut by 2 km^3 of water.

Arfstrom J. D.
A Conceptual Model of Equatorial Ice Sheets on Mars **[#8001]**
I suggest that regional slopes related to the elevation dichotomy of Mars have generated glaciers and ice sheets responsible for erosion and deposition commonly attributed to floods.

Stofan E. R. Lunine J. I. Lorenz R. D. Aharonson O. Bierhaus E. Clark B. Griffith C. Harri A. M. Karkoschka E. Kirk R. Mahaffy P. Newman C. Ravine M. Trainer M. Turtle E. Waite H. Yelland M. Zarnecki J. Hayes A.
Constraining the Role of Seas and Lakes in Titan's Climate: The Titan Mare Explorer Mission **[#8039]**
Lakes and seas on Titan provide the first evidence for an extraterrestrial active liquid cycle and play a key role in its climate. Constraints on Titan's methane cycle, analogous to Earth's hydrologic cycle, can be made through *in situ* measurements.

Lorenz R. D.
Titan is to Earth's Hydrological Cycle what Venus is to its Greenhouse Effect **[#8053]**
Titan serves as an extreme extrapolation of Earth's possible present trend toward more violent rainstorms interspersed by long droughts, much as Venus has acted as a bogeyman to illustrate the perils of enhanced greenhouse warming.

Tobie G. Bezacier L. Bollengier O. Kalousova K. Lefevre A. Oancea A. Bellino G. Marounina N. Monteux J. Le Menn E. Carpy S. Choukroun M. Choblet G. Grasset O. Le Mouélic S. Morizet Y.
Chemical Exchanges Between the Interior and the Atmosphere on Titan and on Other Water-Rich Objects: Implication for Internal Outgassing **[#8055]**
The objective of the present work is to understand the processes that control chemical exchanges in water-rich environments on a wide range of pressure (from Enceladus to Earth-sizes water-rich planets), with Titan as a reference.

Thursday, June 28, 2012
SOLAR EFFECTS ON TERRESTRIAL PLANET CLIMATES
8:30 a.m. Boulderado Ballroom

The Sun's influence on the upper atmospheres of terrestrial planets and implications for atmospheric composition and climate evolution

Chairs: **David Brain**
Stephen Bougher

8:30 a.m. Cravens T. E. *
Solar and Magnetospheric Inputs into Titan's Upper Atmosphere — Comparison with Earth **[#8007]**
Solar radiation and magnetospheric inputs drive atmospheric processes at Titan and Earth. Titan is a satellite of Saturn, whereas Earth resides in the inner solar system. Knowledge of Titan has increased dramatically due to the Cassini mission.

9:00 a.m. Parkinson C. D. * Bougher S. W. Mills F. Yung Y. L.
Photochemical Processes and Their Modeling: A Comparative Planetology Perspective **[#8057]**
Energy deposition significantly affects an atmosphere, causing atmospheric loss and driving photochemical reactions. Special emphasis on photochemical processes and their commonality among the three terrestrial planets (Earth, Venus, Mars) is made.

9:30 a.m. Tian F. *
Atmospheric Escape and Climate of Terrestrial Planets **[#8094]**
Atmospheric escape influenced the evolution of solar system terrestrial planets.

10:00 a.m. BREAK

TERRESTRIAL PLANET EXPLORATION
10:30 a.m. Boulderado Ballroom

The exploration of Venus by Venus Express and the physics of atmospheric processes that are dominant on Venus

Chairs: **Larry Esposito**
Scot Rafkin

10:30 a.m. Svedhem H. * Titov D.
Results from Venus Express **[#8091]**
Venus Express provides a large set of new data on atmospheric parameters in the field of atmospheric dynamics, structure, and chemistry in support of climate studies of the terrestrial planets.

11:00 a.m. Montmessin F. *
Cloud Formation on Terrestrial Planets **[#8042]**
Clouds are one of the most eloquent and most fascinating expressions of atmospheric activity. I will synthesize the most outstanding questions associated with their formation and cycle, but also with their role in climates equilibrium and evolution.

11:30 a.m. Limaye S. S. * Rozoff C.
Vortex Circulations **[#8041]**
Vortex circulations have now been observed on Venus, Mars, Jupiter, Saturn, and even Titan. The host planet atmospheres within which they exist lead to diversity in physical scale, but the basic dynamical properties are being discovered to be similar.

Thursday, June 28, 2012
TERRESTRIAL PLANET CLIMATE
1:30 p.m. Boulderado Ballroom

Influences on terrestrial planet climate and implications for habitability in other solar systems

Chairs: **Mark Bullock**
Raymond Pierrehumbert

1:30 p.m. Zahnle K. J. * Abe Y. Abe-Ouchi A. Sleep N. H.
Venus on the Verge **[#8081]**
Venus's descent into hellish heat must have been caused by its proximity to the Sun. The story of how Venus lost its water becomes: too much sunlight caused a runaway greenhouse effect, any water evaporated, and the hydrogen escaped into space.

2:00 p.m. Toon O. B. *
Impacts by Asteroids and Comets and Their Effects on Planetary Climates **[#8024]**
Impacts of asteroids and comets are major planet-forming events, and have affected planetary climates since the dawn of time. In this talk I will discuss the many effects on the climates of the planets due to this continuous rain of impactors.

2:30 p.m. Bullock M. A. *
Evolution of Venus' Climate and Implications for Terrestrial Exoplanets **[#8092]**
We developed a semi-analytic 1D climate model with clouds to investigate how distance to the star, planetary mass, and the radiative effects of clouds affect the lifetime of oceans on terrestrial planets around other stars.

3:00 p.m. Grinspoon D. H. *
Climate and Habitability on Terrestrial Planets **[#8074]**
Constraining the limits of stellar habitable zones is largely a problem of comparative climatology.

3:30 p.m. BREAK

PLAN FORWARD FOR COMPARATIVE CLIMATOLOGY
4:00 p.m. Boulderado Ballroom

Panel discussion focused on summarizing key research areas identified during the conference and plans for establishing new collaborations

Panel Members: Gerald Schubert, *University of California, Los Angeles (UCLA)*
Raymond Pierrehumbert, *University of Chicago*
Mark Bullock, *Southwest Research Institute (SwRI)*

Notes